Compact discharge based EUV source with high power and long maintenance interval

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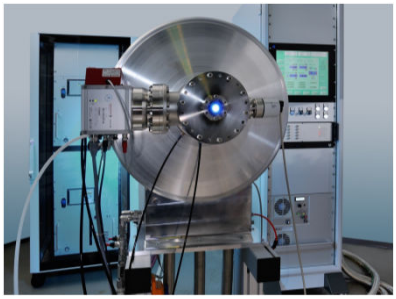
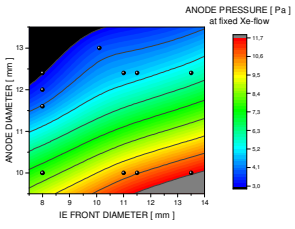
FS5440: 40 W EUV Source

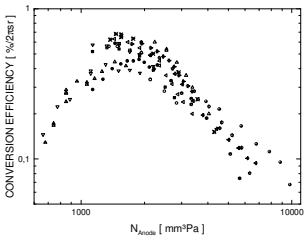


Discharge source FS5440 (source, control unit, chillers)

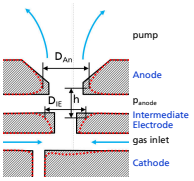
- Max. input power: 15 kW
- Max. pulse energy: 10 J
- Max. repetition rate : 2.5 kHz
- IF-intensity ~40 mW/mm² with matched collector
- Typical plasma length: 3-5 mm
- Typical emission diameter at 13.5 nm: < 300 µm (FWHM)
- Accessible collection angle: > 80°
- Matched debris-mitigation systems available

Scaling of conversion efficiency





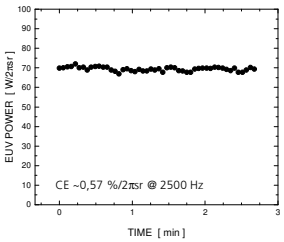
13.5 nm inband conversion efficiency at 3.7 J @ 1 kHz



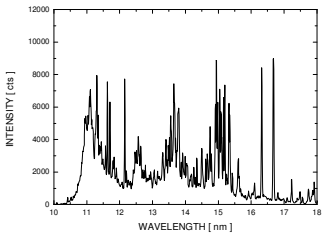
$$N_{Anode} = p_{anode}\frac{h\pi}{12}\left(D_{ie}^2 + D_{ie}D_{an} + D_{an}^2\right)$$

- Measurement of CE for several electrode geometries and materials
- Variation of xenon flow for each set
- Increase of conversion efficiency up to 0.7 %
- Similar behavior when taking N_{Anode} as parameter
- Design-assistance for next generation electrode system

Performance at high input power



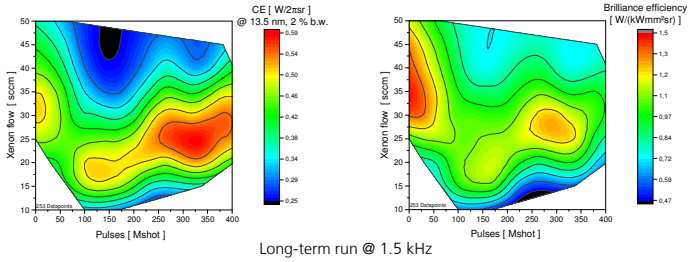
Demonstration of 70 W/2πsr



Typical xenon emission spectrum

- High CE with advanced triggering scalable to >12 kW input power
- Standard deviation (pulse-to-pulse) : σ = 9 %
- Peak brilliance ~15W/mm²sr

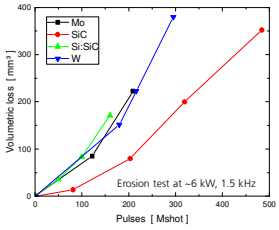
Test with advanced electrode geometry



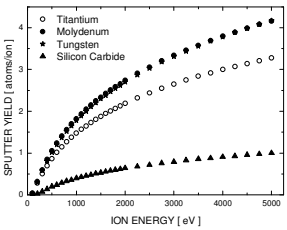
Long-term run @ 1.5 kHz

- Test of prototype with new electrode geometry made from molybdenum
- Successful increase of electrode lifetime by separating discharge from EUV-generating process
- Variation of efficiency can easily be compensated in closed loop operation
- Ongoing test – end of life not reached after 400 Mshot

Material dependence of erosion



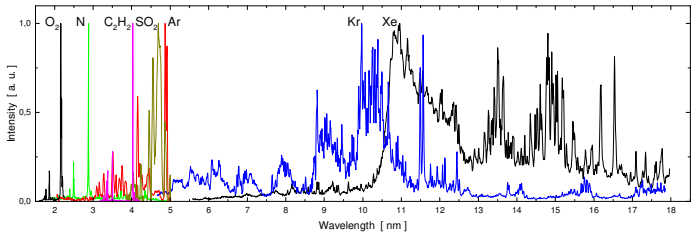
Measured volume loss on different intermediate electrodes in classic design



Simulation of sputter yield of xenon ions on different target materials

- No influence of intermediate electrode material on emission and discharge
- Reduction of erosion of SiC compared to Mo or W is about **2**
- Expected lifetime of combination: SiC and new geometry **>1 Gshot**

Emitter and applications for 1-20 nm



- X-Ray microscopy with nitrogen emission at 2.88 nm
- Next generation EUVL development with krypton at 6.x nm
- Broadband reflectometry for surface analysis

Acknowledgements

Parts of this work have been supported by:

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

ZIM Zentrales Innovationsprogramm Mittelstand